Characterization of Differential Delayed Mortality of Snake River Spring/Summer Chinook Salmon in the Columbia River Estuary

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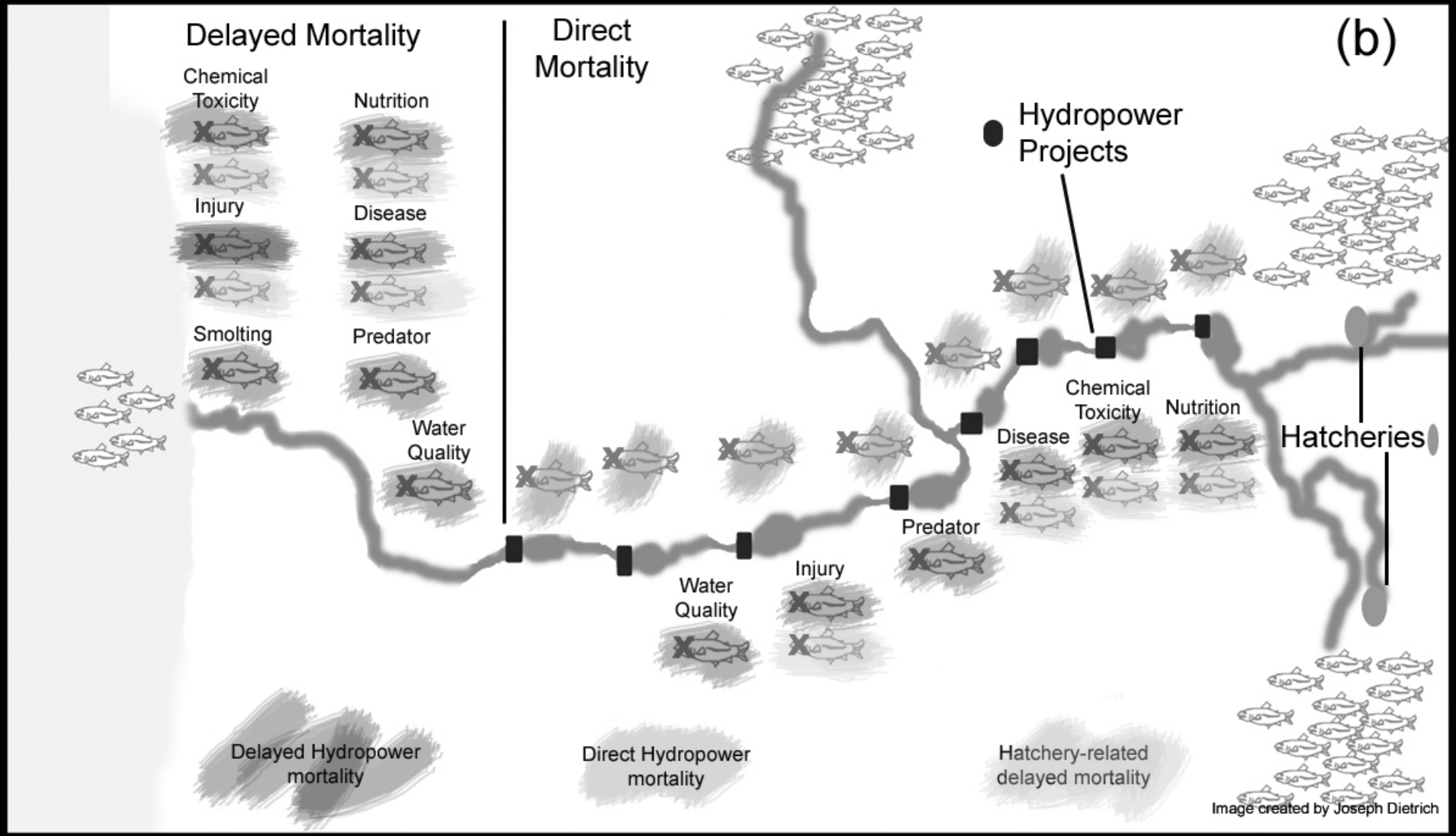
Topics

- Preliminary Data
- Objectives
- Study Design
- Preliminary Results
- Preliminary Conclusions

Delayed Mortality



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- Mitigating Strategies
  - Barging
  - Juvenile fish passage & collection facilities
  - Predator control
  - Flow augmentation
  - Reservoir drawdown

Observed Differential Delayed Mortality in Snake River Spring/Summer Chinook

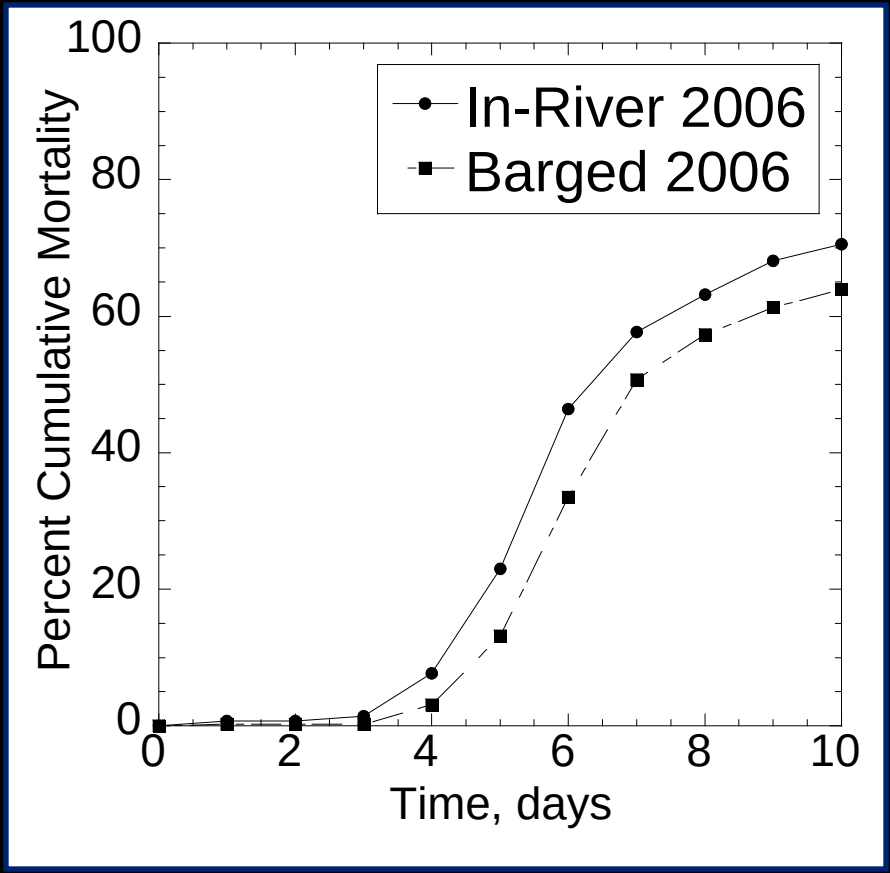
	Dworshak Hatchery		Rapid River Hatchery		McCall Hatchery	
Year	T/C	D	T/C	D	T/C	D
1997	1.77	0.89	1.72	0.60	1.39	0.63
1998	0.72	0.38	1.67	1.02	1.96	1.16
1999	0.99	0.61	1.29	0.80	1.50	0.86
2000	0.99	0.53	1.32	0.82	1.90	1.24
2001	9.00	2.23	21.80	7.42	31.00	8.72
2002	1.24	0.84	1.51	1.14	1.45	0.88

$$T/C = SAR_2(T_0)/SAR(C_0)$$

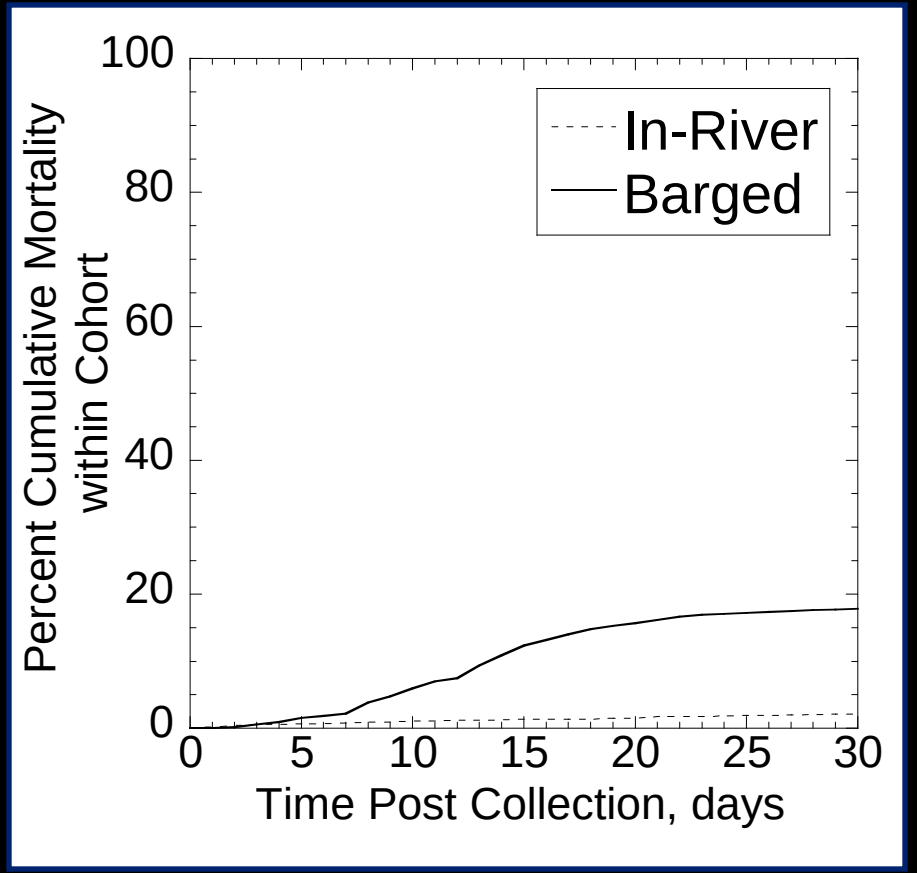
$$D = \frac{SAR_2(T_0)}{V_t} \Big/ \frac{SAR(C_0)}{V_c}$$

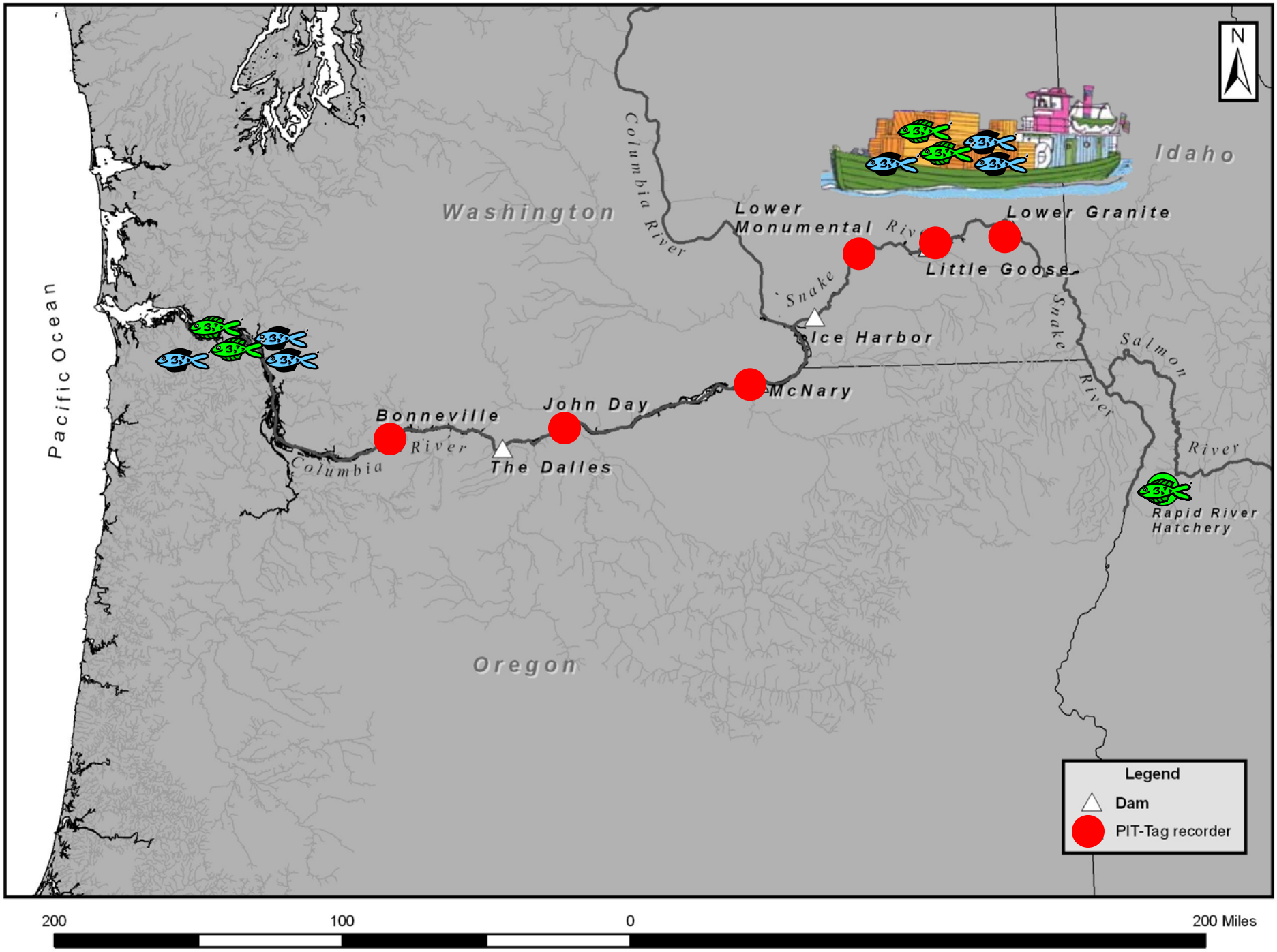
Potential Role of Infectious Disease on Observed *D*

FY06: Disease challenge



FY06: Prior to disease challenge




N
Pacific Ocean
Washington
Oregon
Idaho
Columbia River
Snake River
Salmon River
Columbia River
Lower Monumental
Lower Granite
Little Goose
Ice Harbor
McNary
John Day
Bonneville
The Dalles
Rapid River Hatchery
Legend
Dam
PIT-Tag recorder
200
100
0
200 Miles

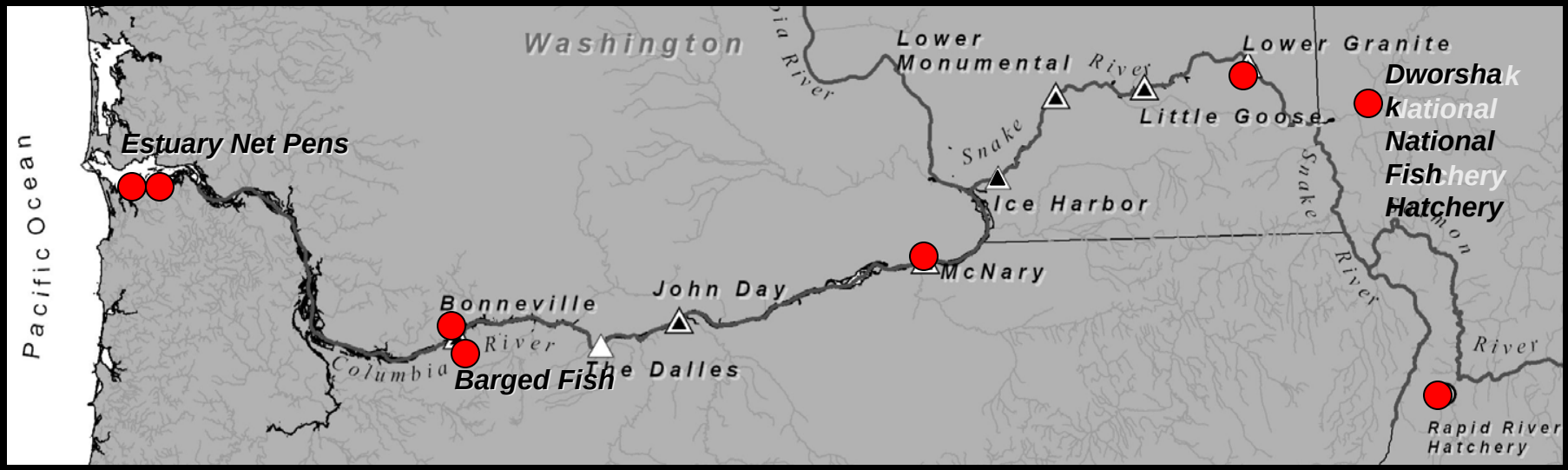
Objective

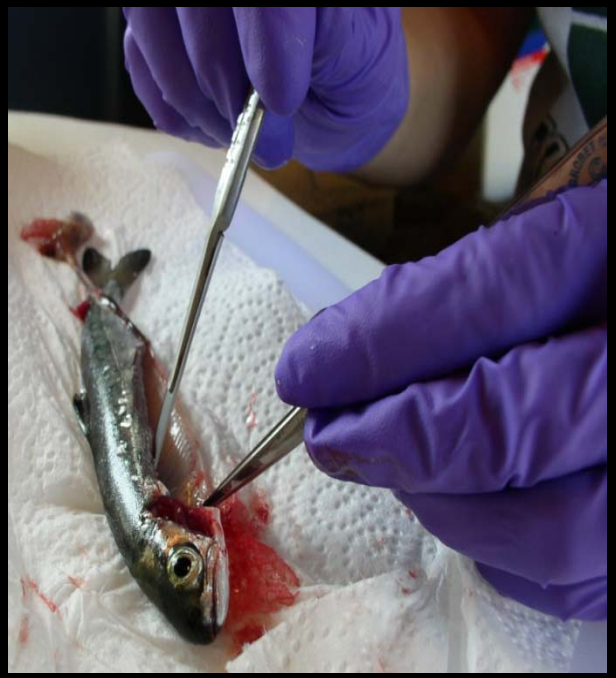
- Characterize differential-delayed mortality in the estuary
  - Extent
    - Using net-pens
  - Causes
    - Histopathology
    - Pathogen prevalence
    - Immune Function
    - Hematology

Estuary Net Pens

- Description:
  - 2 estuary net pen sites
  - Barged and in-river fish placed in net pens
  - Fish held for 28 days
- Extent:
  - Mortalities collected daily
- Causes:
  - Histopathology
  - Pathogen prevalence
  - Immune Function
  - Hematology

Collection of Fish from River System





- Spatial and Temporal monitoring
  - Water quality
    - Temperature, DO, pH, pathogens
  - Pathogens in both fish and water
  - Immune function
  - Whole body chemistry
    - Contaminants
    - Lipids

Pathogen Targets

- Bacteria
  - *Aeromonas hydrophila*
  - *Aeromonas salmonicida*
  - *Flavobacterium columnare*
  - *Flavobacterium psychrophilum*
  - *Renibacterium salmoninarum*
  - *Listonella anguillarum*
  - *Yersinia ruckeri*
- Fungal
  - Saprolegnia (Family Saprolegniaceae)

Estuary Arrival Timing Influenced Extent of Differential Delayed Mortality

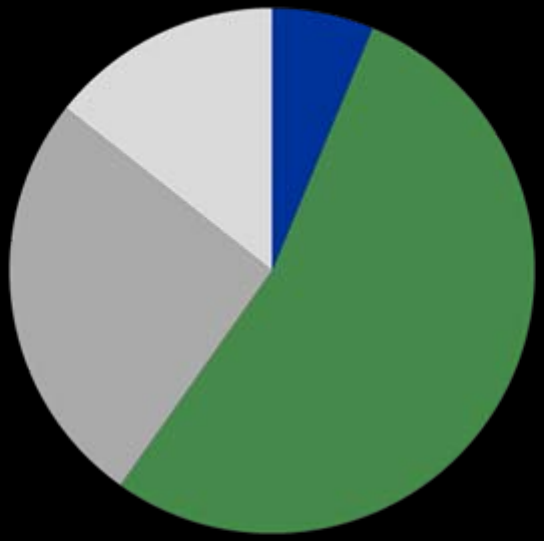
	Cumulative Mortality		
Mortality Period	**Barged**	**In-River**	**Barged Vs In-River**
Prior to May 26	14.2%	4.7%	11.1%
After May 26	23.1%	48.8%	-30.0%

Extent of Differential Delayed Mortality Between Hatcheries with Fish Arriving Before May 25, 2007

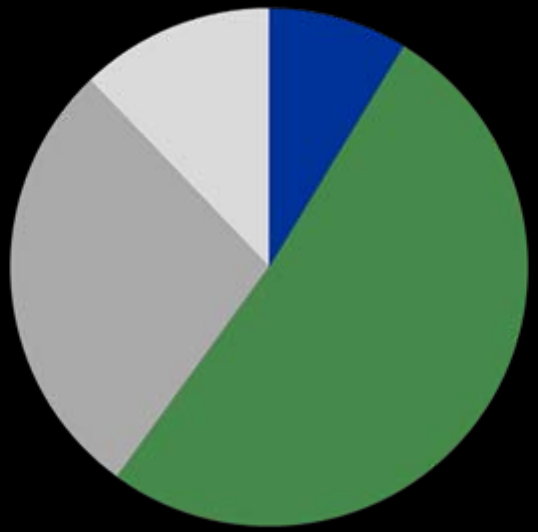
Percent Mortality						
	Barged		In-River		Differential Mortality	
Duration of Holding	Dworshak Hatchery	Rapid River Hatchery	Dworshak Hatchery	Rapid River Hatchery	Dworshak Hatchery	Rapid River Hatchery
4-day	6.9%	2.3%	0.8%	1.0%	6.1%	1.3%
8-day	13.8%	6.3%	2.4%	2.7%	11.4%	3.6%
12-day	16.8%	8.8%	4.9%	5.1%	11.9%	3.7%
Overall Holding	19.4%	9.9%	5.7%	5.5%	13.7%	4.4%

Histopathology Results of Morbid Net Pen Fish

Barged



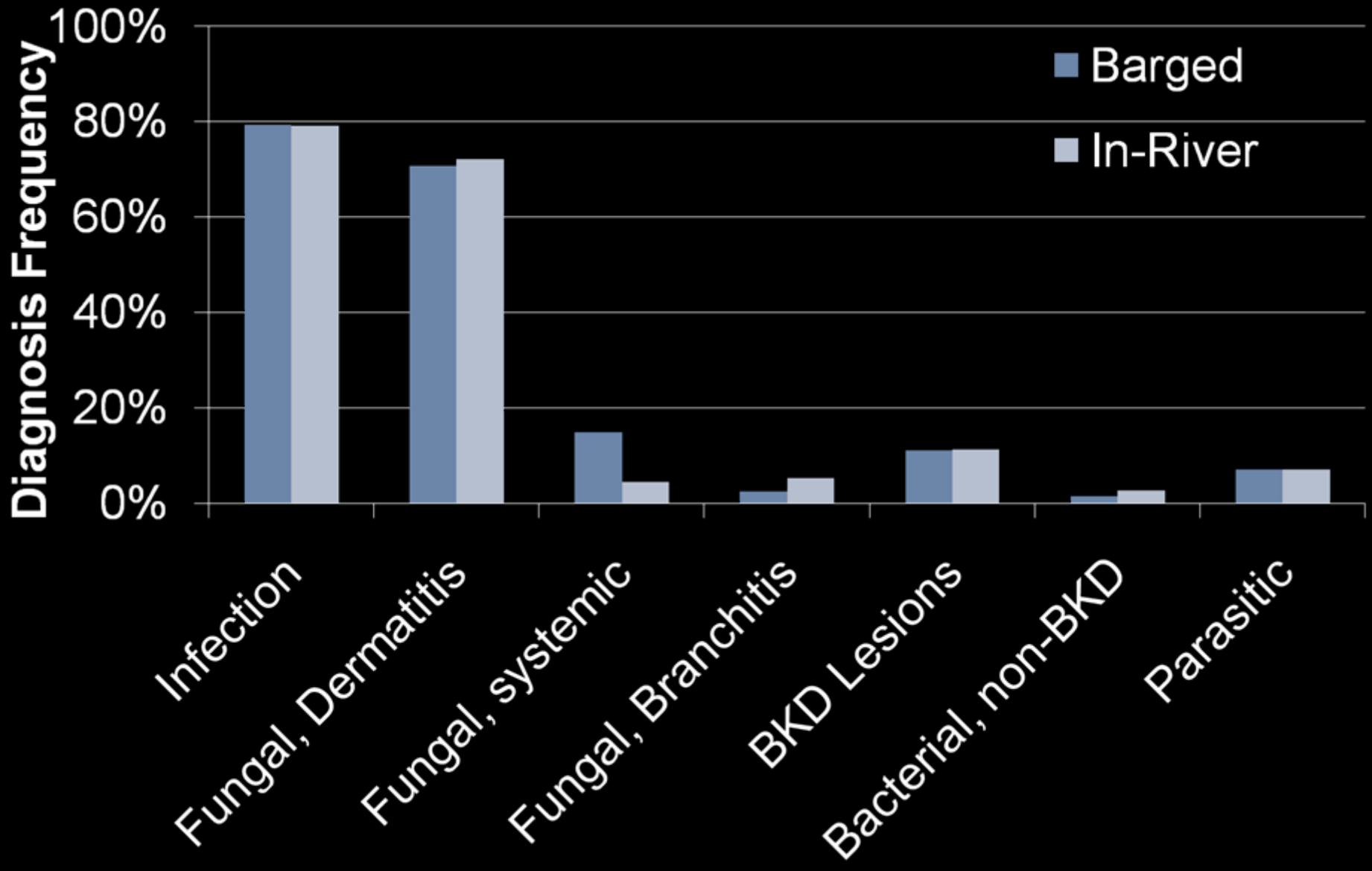
In-River



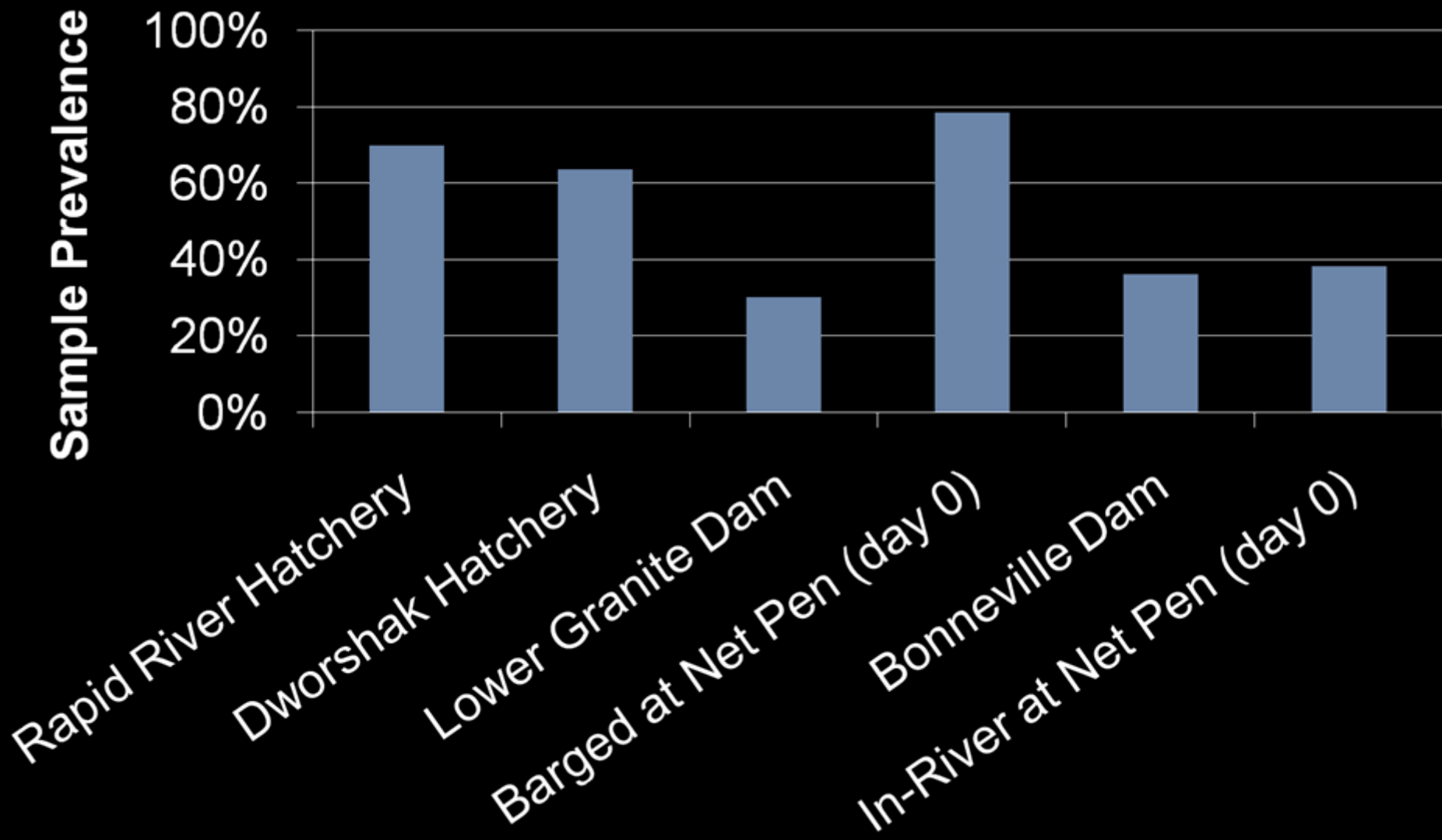
- Metabolic Distress Only
- Infection Only
- Metabolic Distress & Infection
- Unknown

⇒85% ID+MD

Histopathology: Specific Diagnosis in Morbid Net Pen Fish



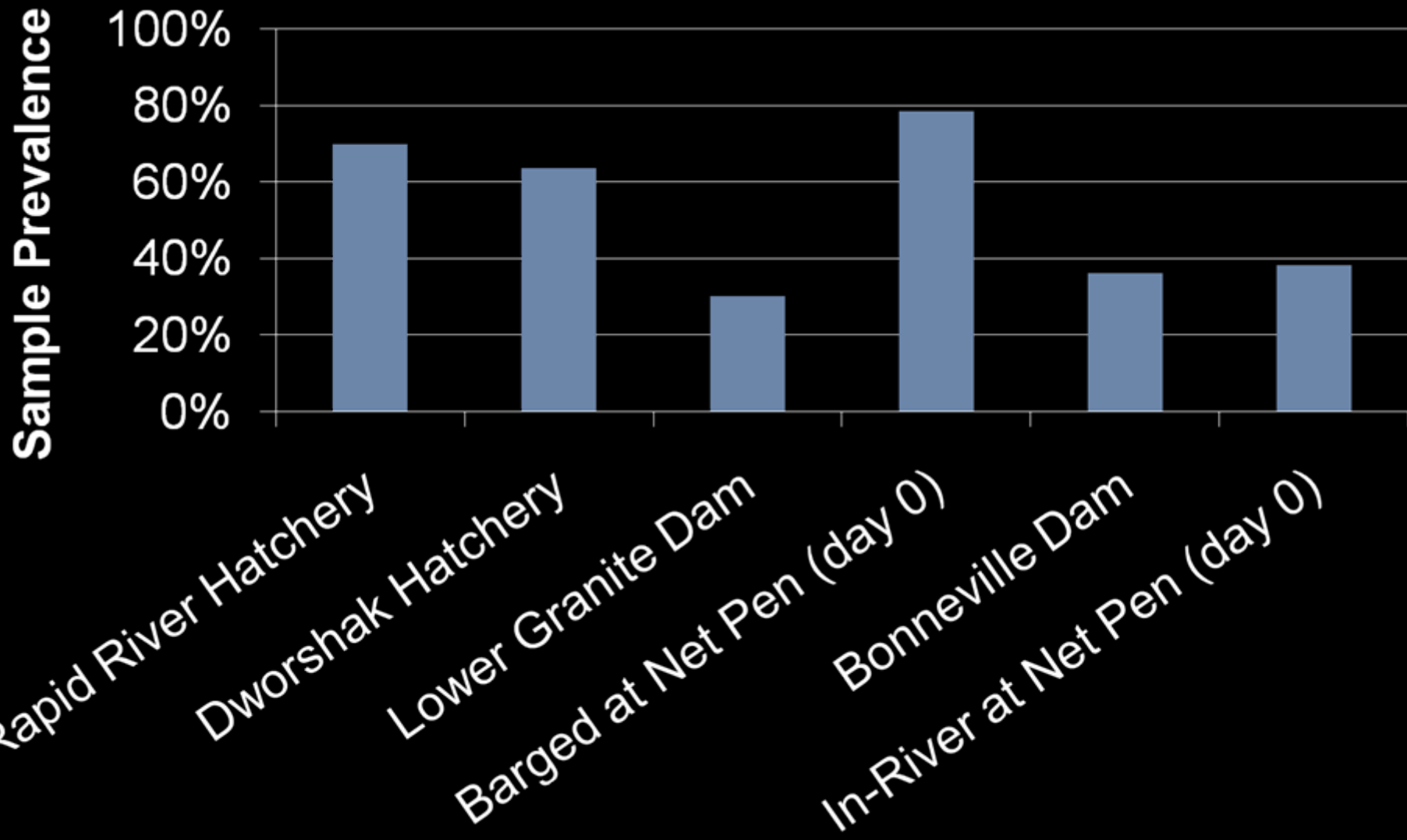
Preliminary Pathogen Screening: PCR Detection of *Renibacterium salmoninarum*



Difference in Infection Rates in Morbid Fish at Net Pens

Pathology Diagnosis Frequency			
	Barged	In-River	Difference
Metabolic Distress Only	6.3%	8.7%	-2.4%
Infection Only	53.5%	51.3%	2.2%
Infection & Metabolic Distress	25.8%	27.8%	-2.0%
Fungal Dermatitis	70.6%	72.2%	-1.6%
Fungal Branchitis	2.5%	5.2%	-2.7%
Fungal, systemic	14.8%	4.3%	10.5%
Bacterial, non-BKD lesions	1.5%	2.6%	-1.1%
Bacterial, BKD lesions	11.0%	11.3%	-0.3%
PCR Detection Frequency			
	Barged	In-River	Difference
Renibacterium salmoninarum	78.5%	38.4%	40.1%

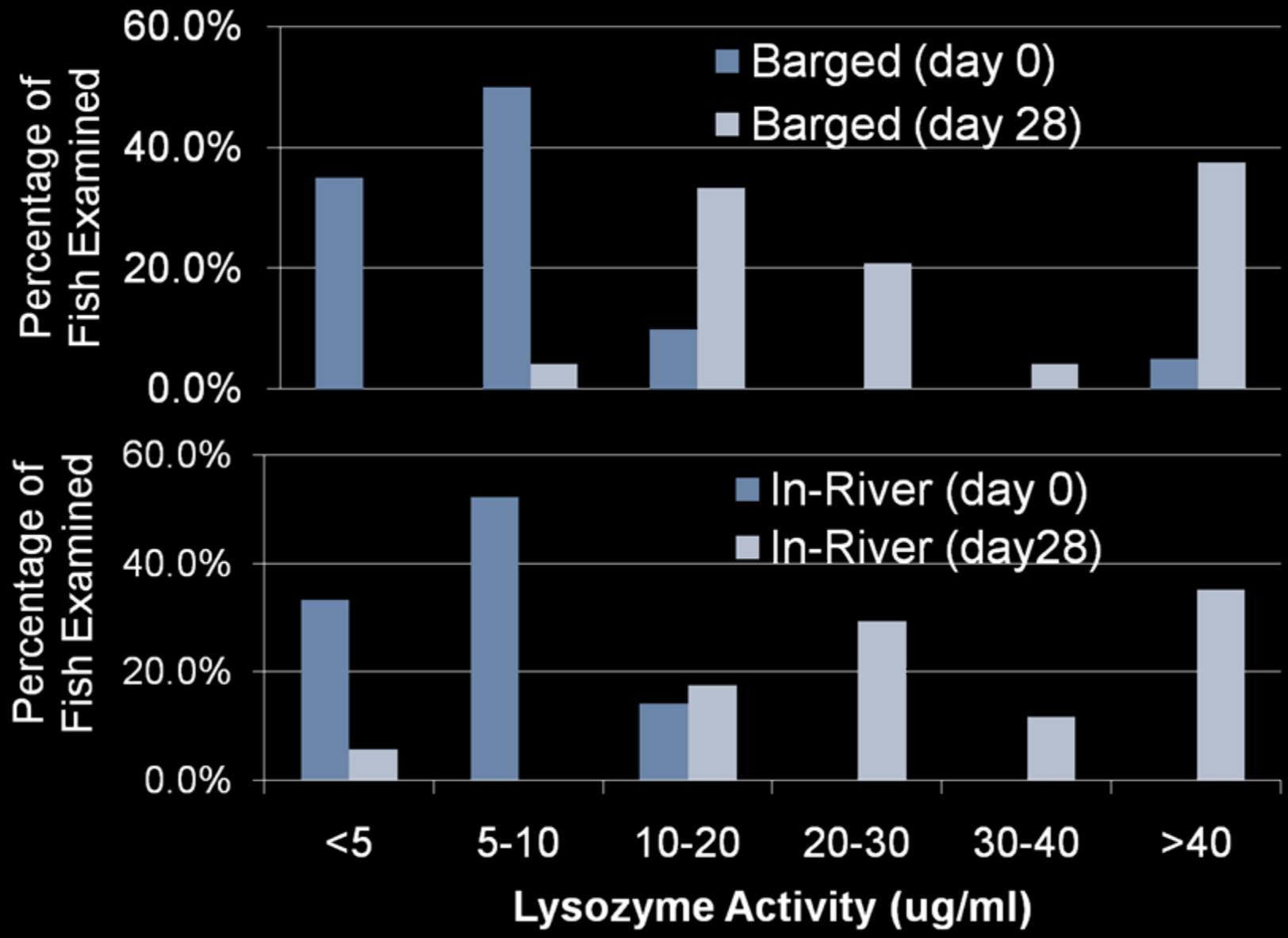
Potential Impact of Barging on Prevalence of *Renibacterium salmoninarum*



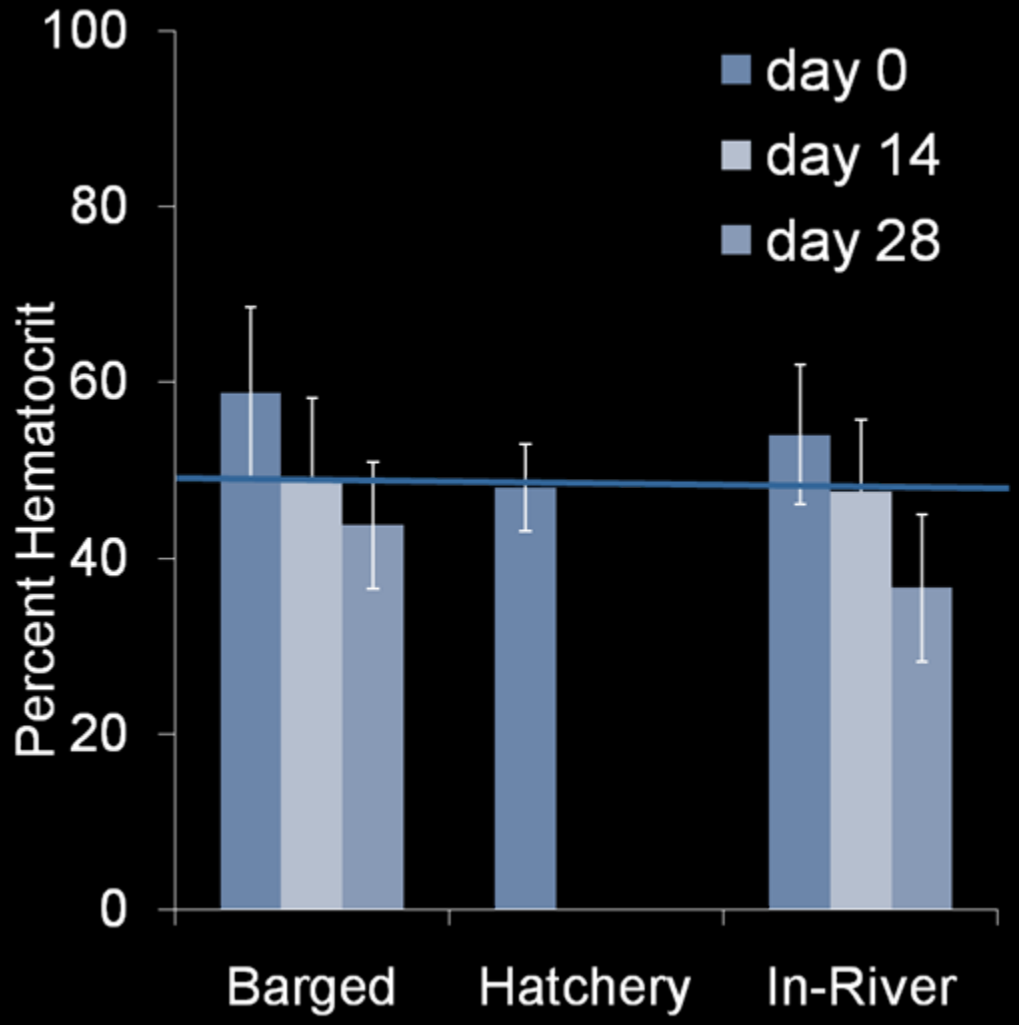
Potential Impact of Barging on Prevalence of Systemic Fungal Infections

Prevalence of Saprolegnia in Barged Fish	
Lower Granite	Net Pens
6.4%	14.8%

Immune Function: Lysozyme Activity



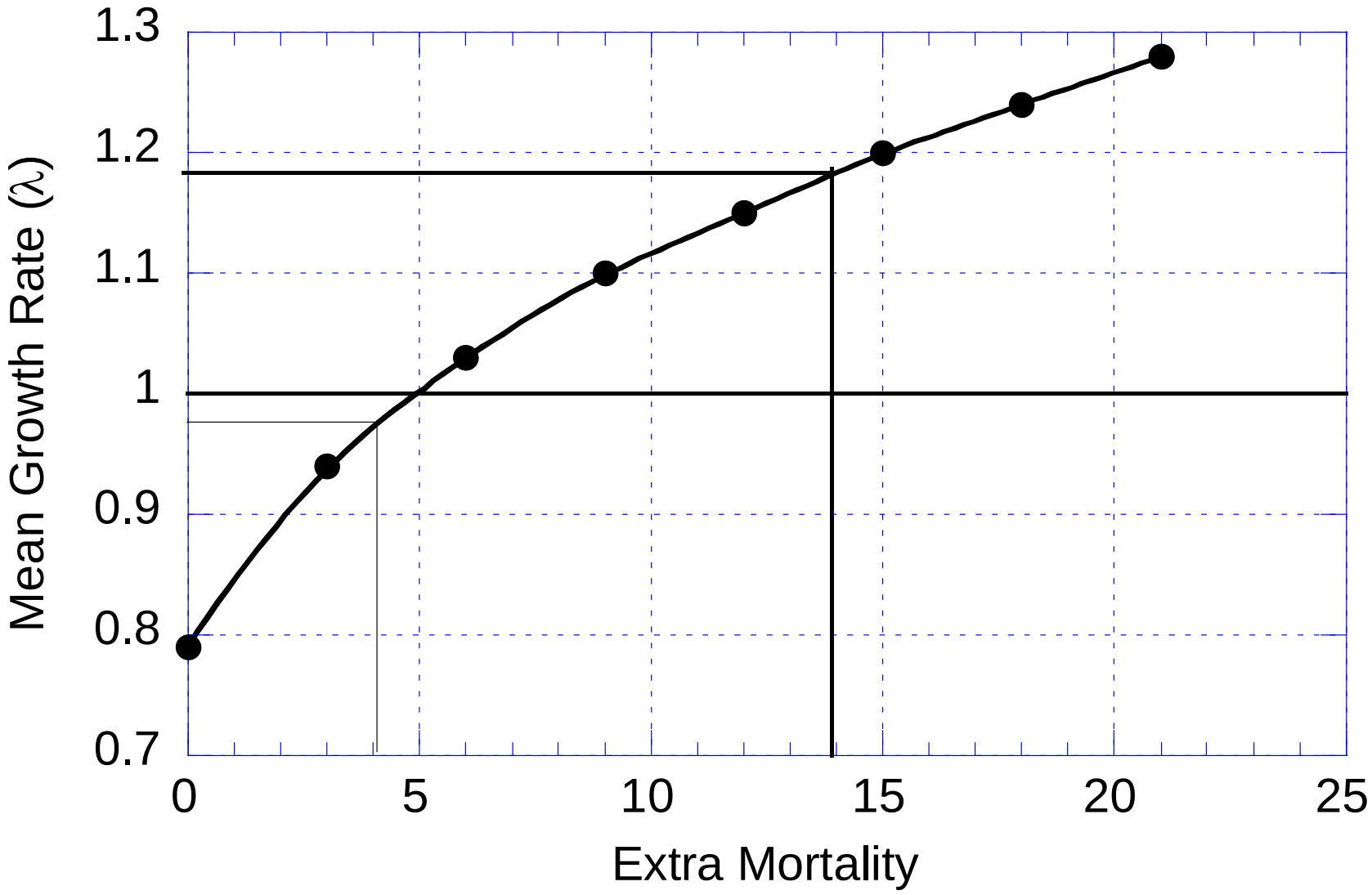
Hematology: Hematocrit Measurements



Significance of Heath Status on Differential Delayed Mortality *D*

Year	Dworshak Hatchery Measured *D*		Improvement in Health		Revised *D*
	D				
1997	0.89	+	0.137	=	1.03
1998	0.38	+	0.137	=	0.52
1999	0.61	+	0.137	=	0.75
2000	0.53	+	0.137	=	0.67
2002	0.84	+	0.137	=	0.98

Management Implications



Preliminary Conclusions

- Barging late season outmigrants improves survival in the estuary
- Incidence of differential delayed mortality was largely associated with differences in infection of *R. salmoninarum* and systemic mycosis
- Infectious diseases appear transmitted during transport by barge
- Observed incidence (13.7, 4.4) on *D* could be substantial, but significance unclear

Preliminary Pathogen Screening: PCR Detection of Bacteria

- *Yersinia ruckeri*
  (6 positive kidney samples)
- *Listonella anguillarum*
  (2 positive kidney samples)
- *Aeromonas hydrophila*
  (1 positive kidney sample)
- No positive kidney samples for:
  - *Aeromonas salmonicida*
  - *Flavobacterium columnare*
  - *Flavobacterium psychrophilum*

2007 Project Status

- Pathogen Prevalence
  - 2639 fish sampled
    - 28% of kidneys screened for 7 bacteria by PCR
- Chemical Body Burdens
  - 40 composite samples collected
    - 100% of sample analyses completed
- Delayed Net Pen Mortality
  - 1915 mortalities collected
    - 46% subjected to pathology screening
  - 890 immune function samples collected
    - 15% of samples analyzed

Factors Contributing to Decline

NRC (1996)

- Habitat degradation
- Over harvest
- Hydropower operation
- Hatchery production

Biological Opinion

- Predation
- Disease
- Chemical toxicity
- Water quality
- Nutrition
- Injury
- Physiological stresses associated with smoltification

Factors Affecting Fish Health

- Water quality
- Nutrition
- Injury
- Disease exposure
- Chemical contaminant exposure
- Physiological stress

2007 Tasks

- Extent of differential delayed mortality
  - Monitor survival of Barged and In-River fish in estuary net pens
- Causes of differential delayed mortality
  - Monitor pathogen prevalence during outmigration and estuary holding
  - Monitor whole body chemistry during outmigration and estuary holding
  - Monitor immune function in estuary
  - Perform pathology screening on all mortalities

Immune Function: Lysozyme Activity

- Lysozyme activity levels begin (day 0) low and increase in both groups in response to net pen stressors
- At start: a small percentage of Barged fish have high activity levels
  - Fish ARE responding to a previous stressor
- At end: a small percentage of In-River fish have low activity levels
  - Fish are NOT responding to net pen stressors

Preliminary Results From FY07: Pathology of Net Pen Mortalities

- Infection diagnosis rate greater than metabolic distress rates for both Barged and In-River fish
- Barged population has a greater infection diagnosis rate than In-River population
- Greatest difference is systemic fungal infections

Whole Body Chemistry: Lipids

Whole Body Lipids		
	Rapid River Hatchery	Dworshak Hatchery
Hatchery	4.7%	7.0%
Lower Granite Dam	1.7%	2.6%
McNary Dam	1.2%	0.7%
Bonneville Dam	0.5%	0.8%
Post-Barging	1.2%	1.5%

Whole Body Chemistry: Contaminant Exposure

- Detectable levels of most contaminants found in all composites
  - DDT, PCBs, PAHS, PBDEs
- Lipid-adjusted concentrations greater for In-River fish
- Decreased concentrations at conclusion of estuary holding may be indicative of mortalities in high exposure groups